



**BAE SYSTEMS**

# **ANSER Technologies - UAV Applications**

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**(with thanks to Dr. Julia Sutcliffe, BAE Systems Australia)**

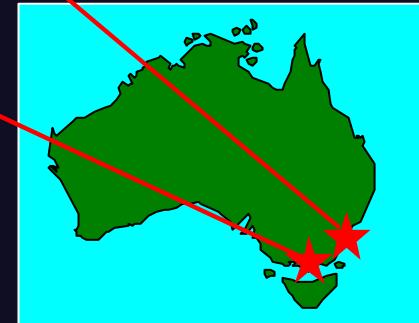
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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE <b>02 SEP 2003</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>ANSER Technologies - UAV Applications</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>BAE Systems Australia</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>See also ADM001676, UAV 2002 Conference &amp; Exhibition., The original document contains color images.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>UU</b>	18. NUMBER OF PAGES <b>22</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# ANSER Background

**BAE SYSTEMS**

- **BAE SYSTEMS Research and Demonstration Programme**
  - **Network Centric Warfare Technologies**
  - **Autonomous Operations Technologies**
- **Element of BAE SYSTEMS Strategic Options Programme**
- **Collaboration between**
  - **BAE SYSTEMS - ATC Sowerby**
  - **University of Sydney - Australian Centre for Field Robotics**
  - **BAE SYSTEMS Australia - Missiles & Decoys**
- **Primary Activities in Australia**
- **Culmination of over 10 years of focused research**



# ANSER FOCUS

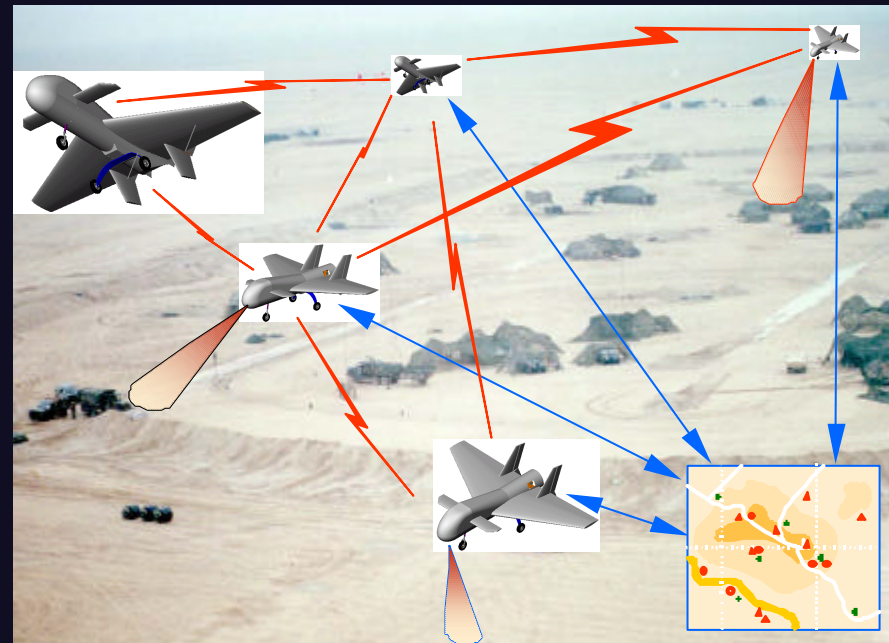
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- **Current Focus (Phase 1)**

- Multi-platform / Multi-sensor Data Fusion
- Multi-Platform Picture Compilation (Situational Awareness)
- Improved Navigation and Target Location accuracy
- GPS Denied Operations

- **Future Focus (Phase 2)**

- Decentralised Control
- Sensor / Platform Coordination
- Multi-platform Co-operation

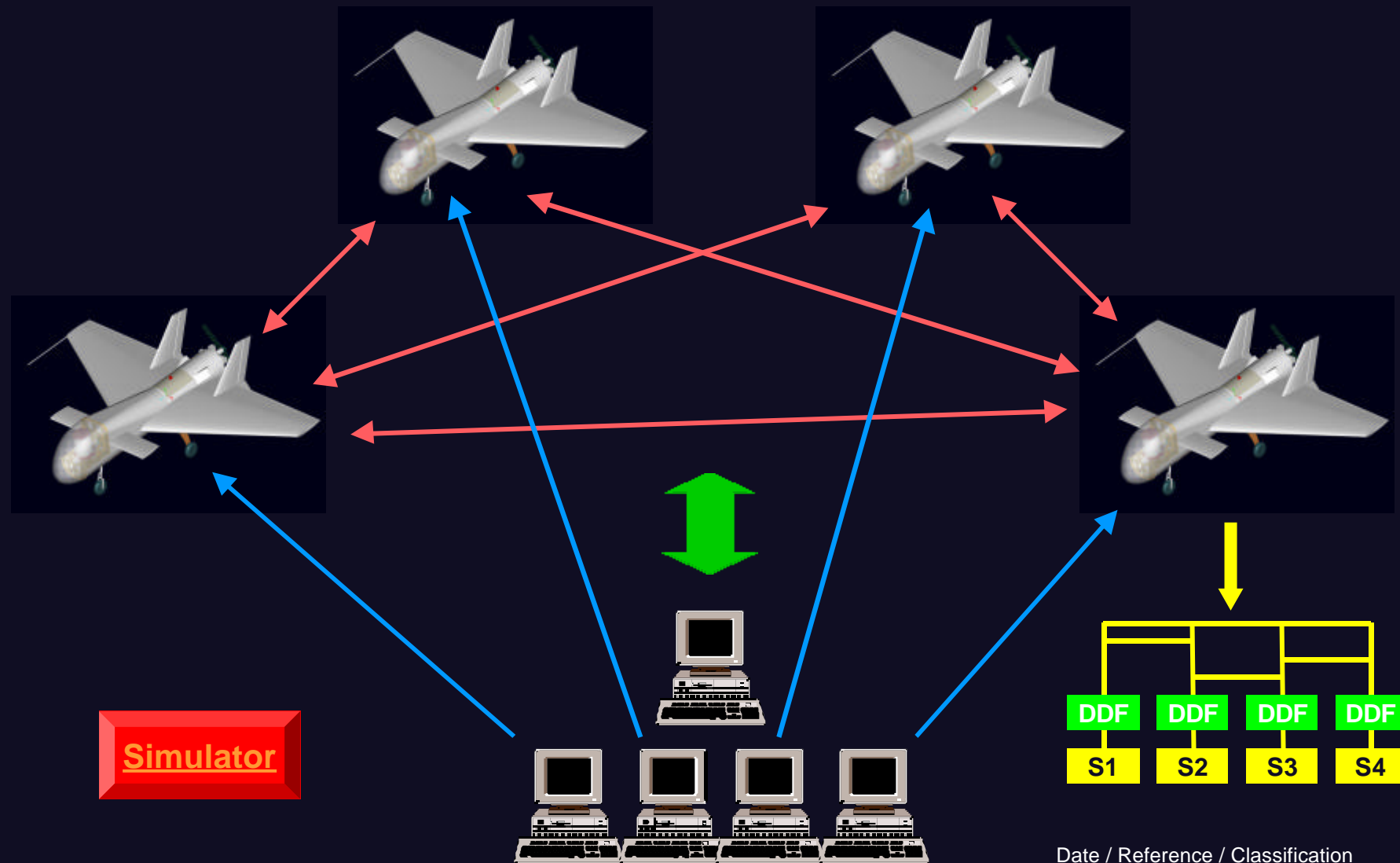


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- **Decentralised Data Fusion (DDF)**
- **Simultaneous Localisation and Map-building (SLAM)**

# ANSER Demonstration and Systems

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# Focus of this Presentation

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- Achieving Accurate Navigation and Target Location in a GPS Denied Environment through

**SLAM**

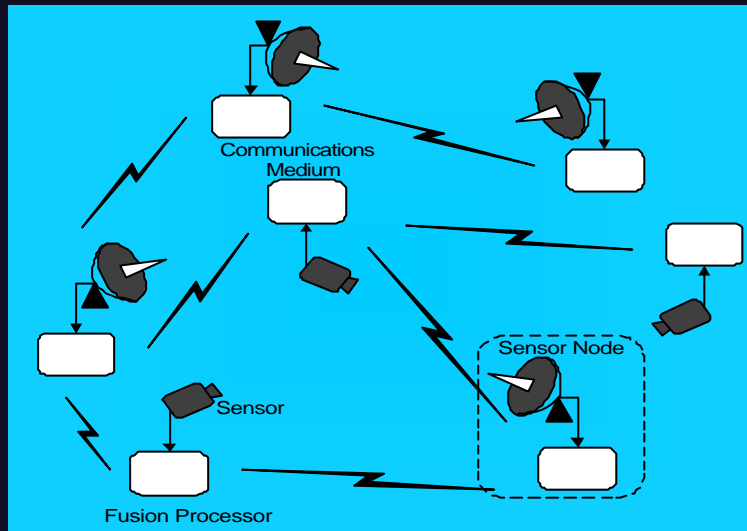
- Single Sensor
- Multi-Sensor

**DDF**

- Single Platform
- Multi-Platform

# What is a DDF system?

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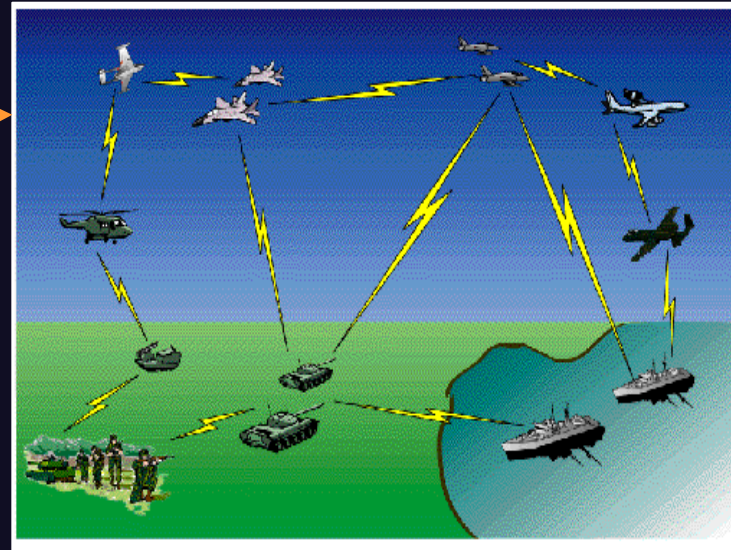


## Decentralised system

- network of sensor nodes
- local observations
- communication between neighbouring nodes

## Constraints implemented

- no central fusion centre
- no common comms facility
- no global knowledge



Classification



# DDF node structure and function

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- Employ Information filter forms:
  - Inverse Covariance (Fisher)
  - Log of probability ratio (Shannon)

Measure Compactness  
of Information

Fusion of:

Local observation information

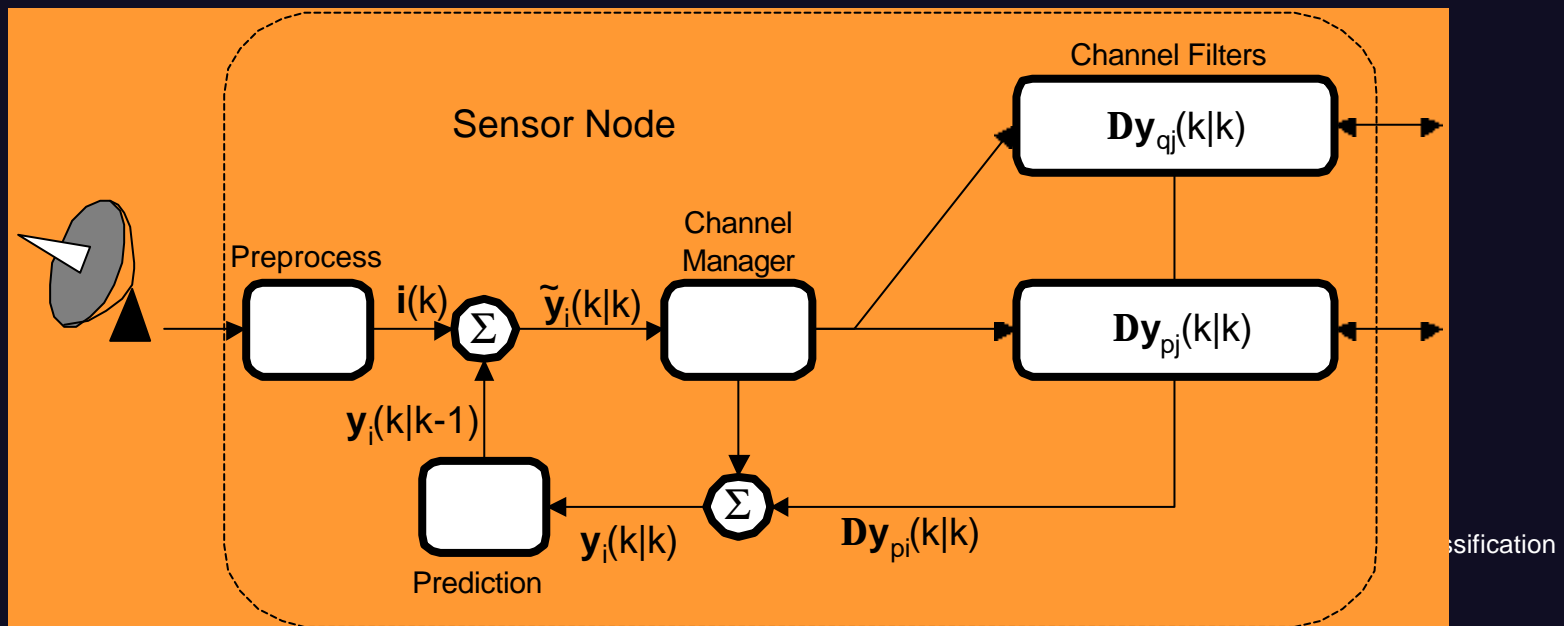
Local prediction information

Communicated information gain

Channels:

Assimilate local information

Communicate information gain.

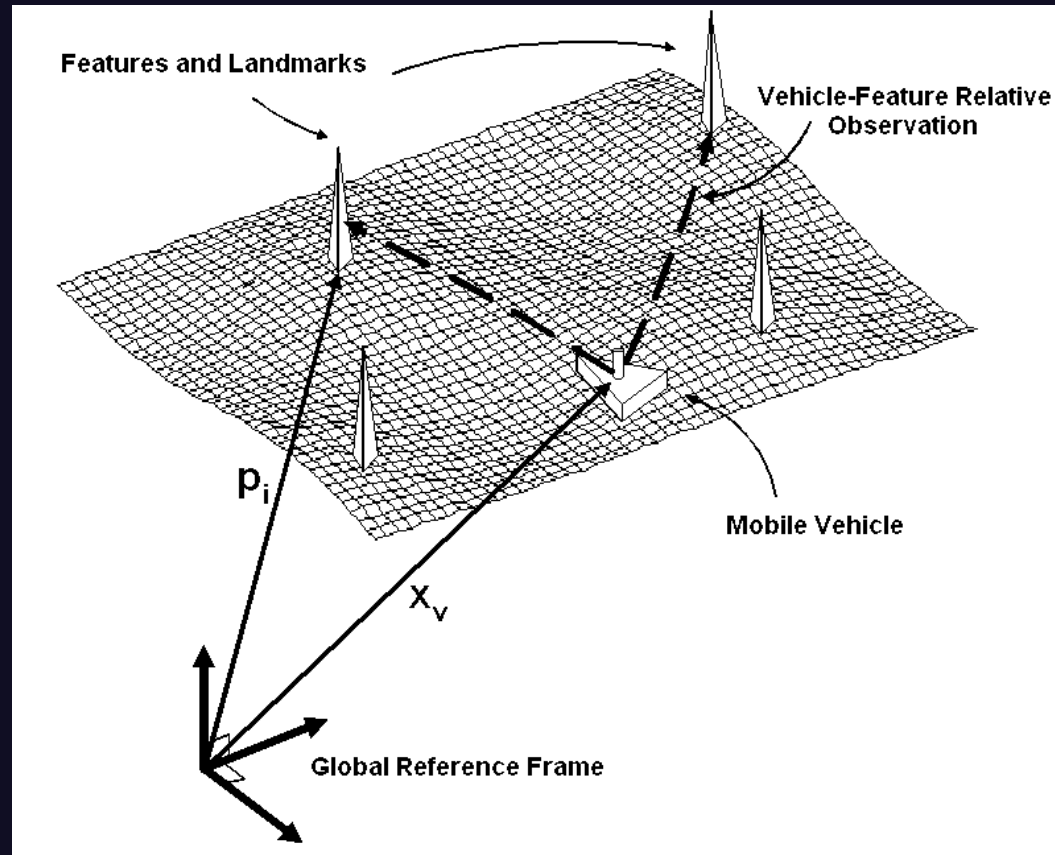


# SLAM

## Simultaneous Localisation and Map-building

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### Problem Structure

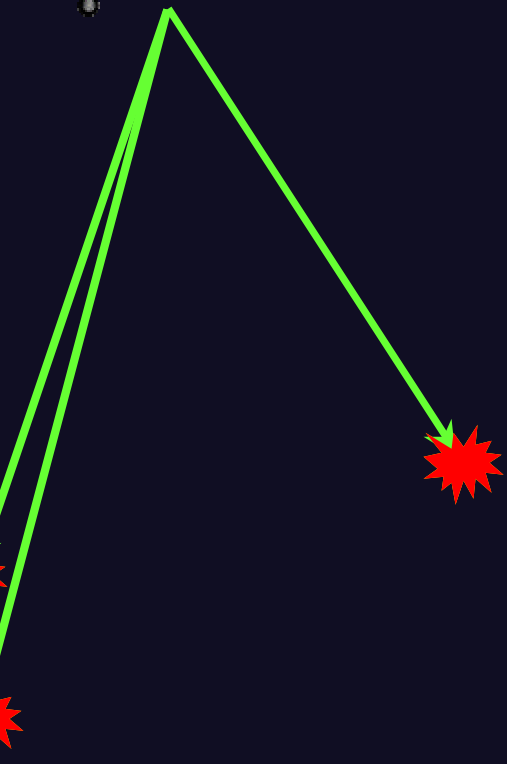


- Unknown location  
(no GPS).
- Unknown environment  
(no map).
- Build a relative map (of features and targets).
- Use that map to navigate.

### Hybrid of two problems:

- target tracking
- map navigation.

Predict



Predict



Re-observe

Correlate



Predict



Re-observe

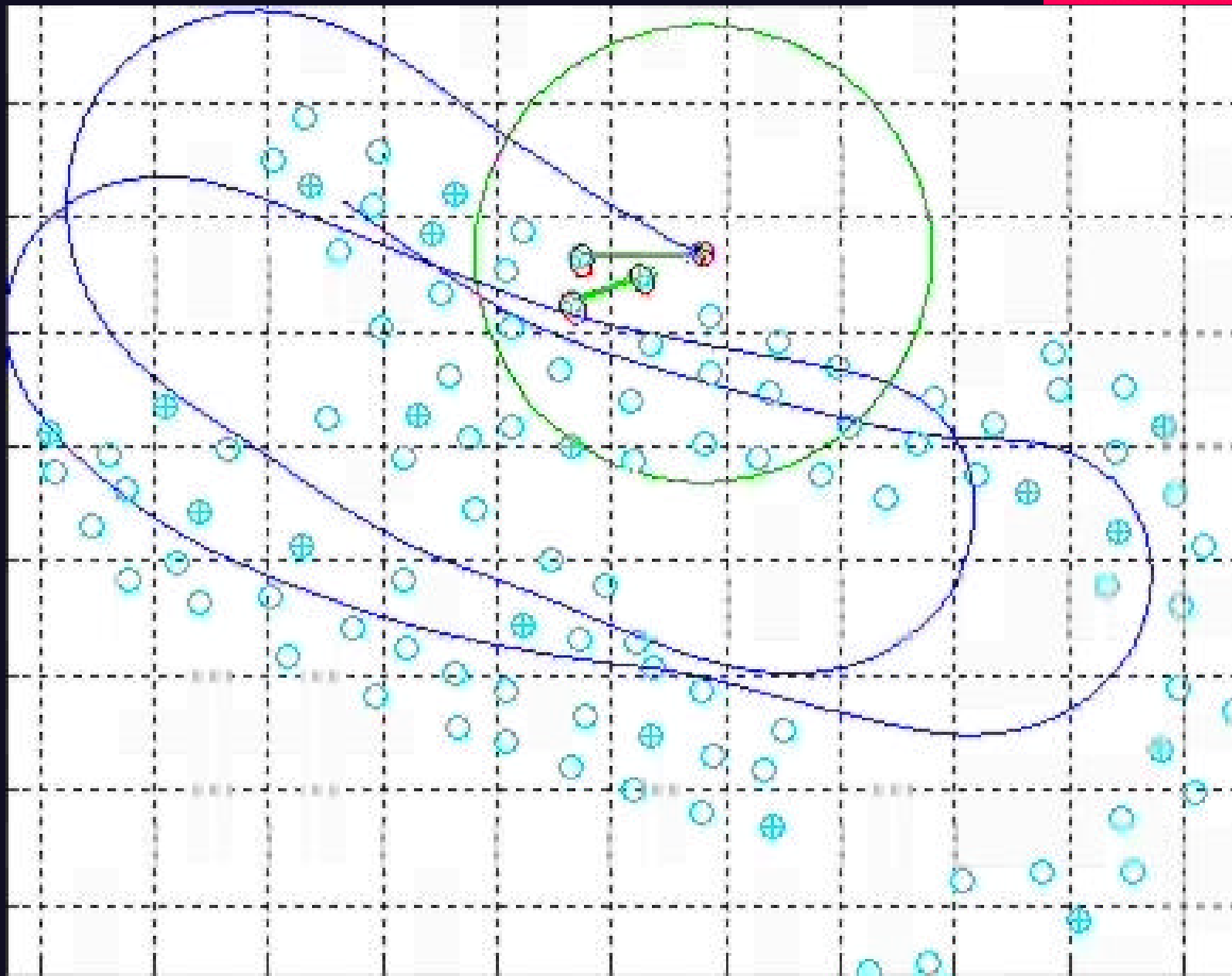


Correlate

Correlate

# SLAM in Flight

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# SLAM Performance

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**Correlations between landmarks increase monotonically.**

**The SLAM algorithm can create a perfect relative map of landmarks.**

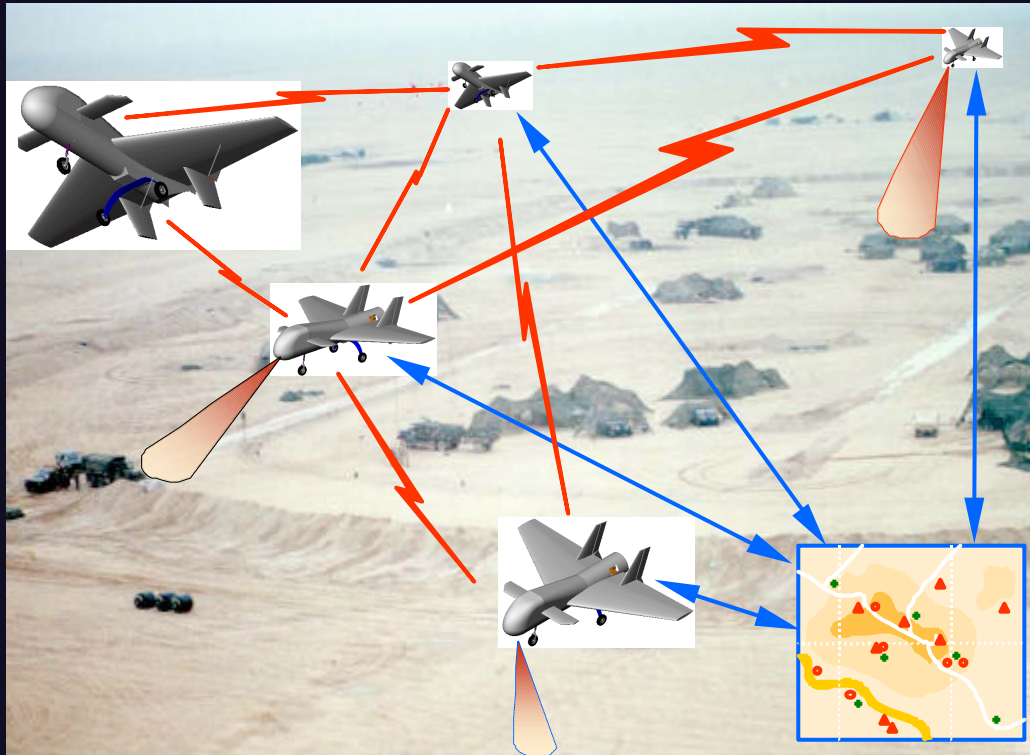
**The SLAM algorithm bounds platform pose error.**



**Reduced Reliance on GPS**

# Combining DDF with SLAM

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In Information or *decentralised* form, maps can easily be shared between platforms.

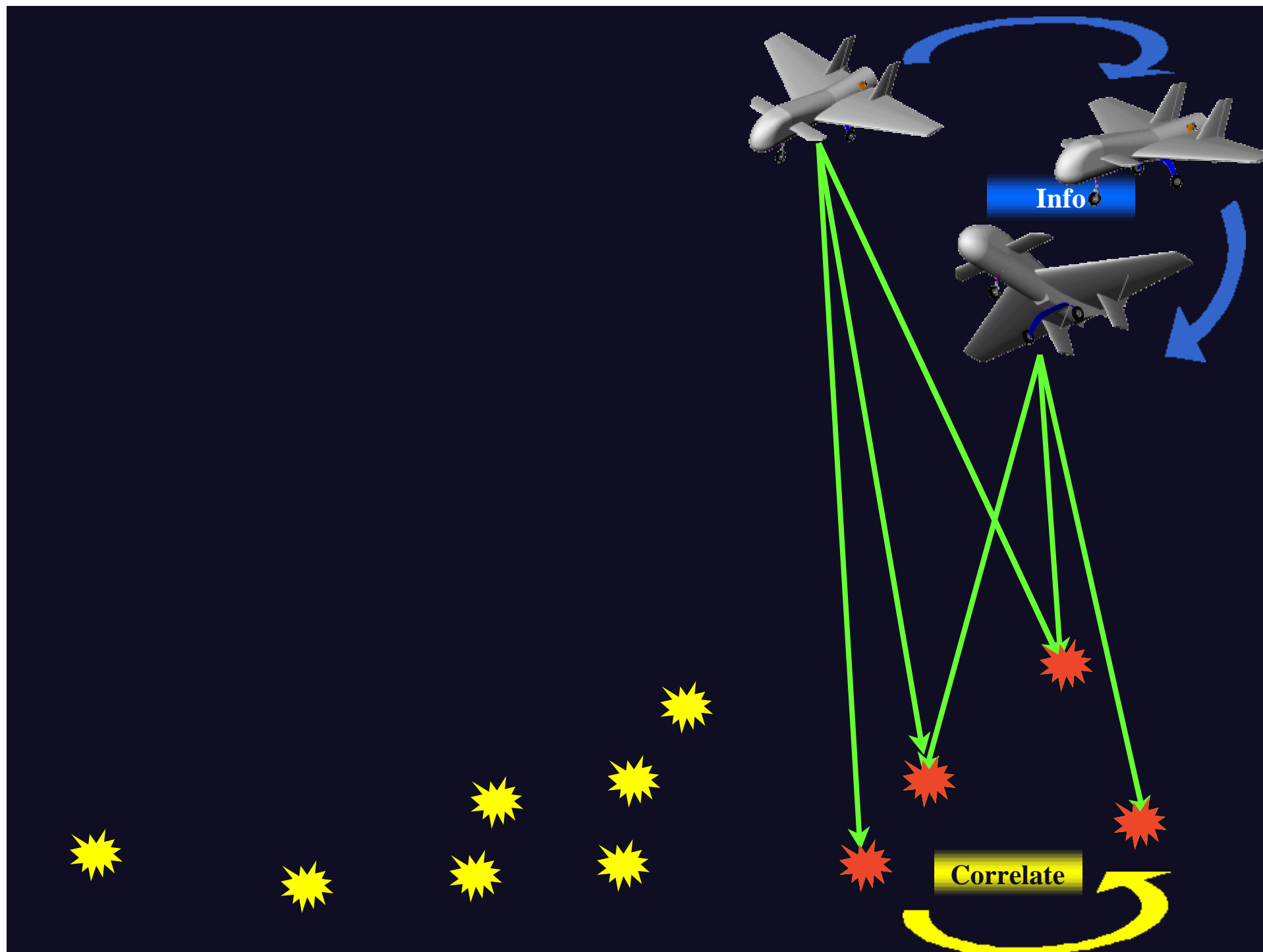
Partial maps can be communicated.

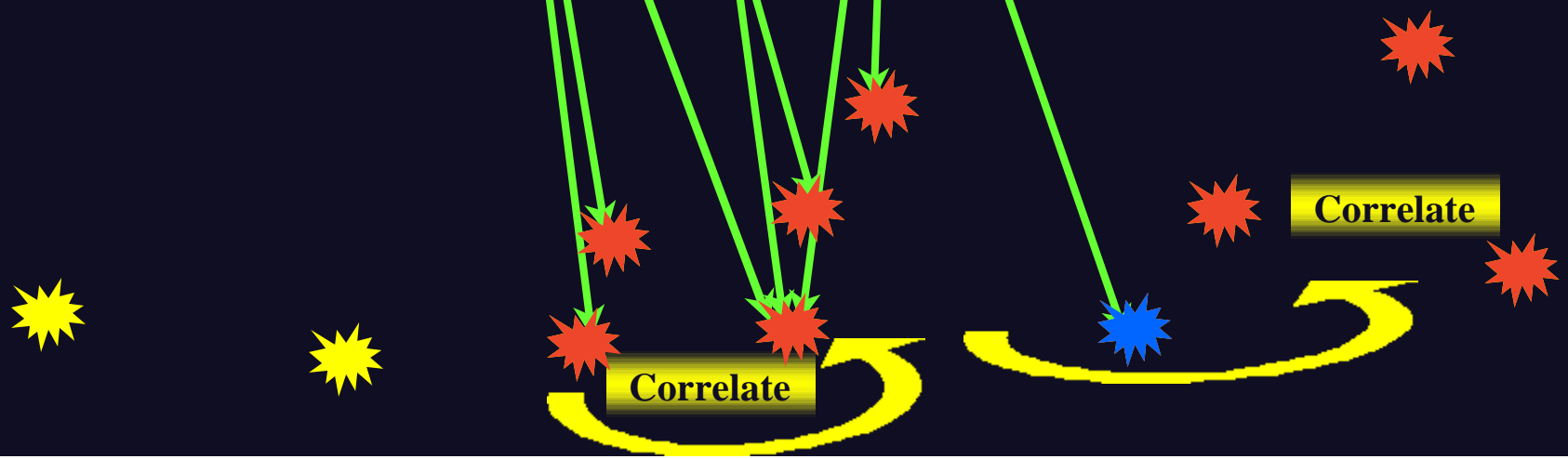
Asequent map data can be employed.

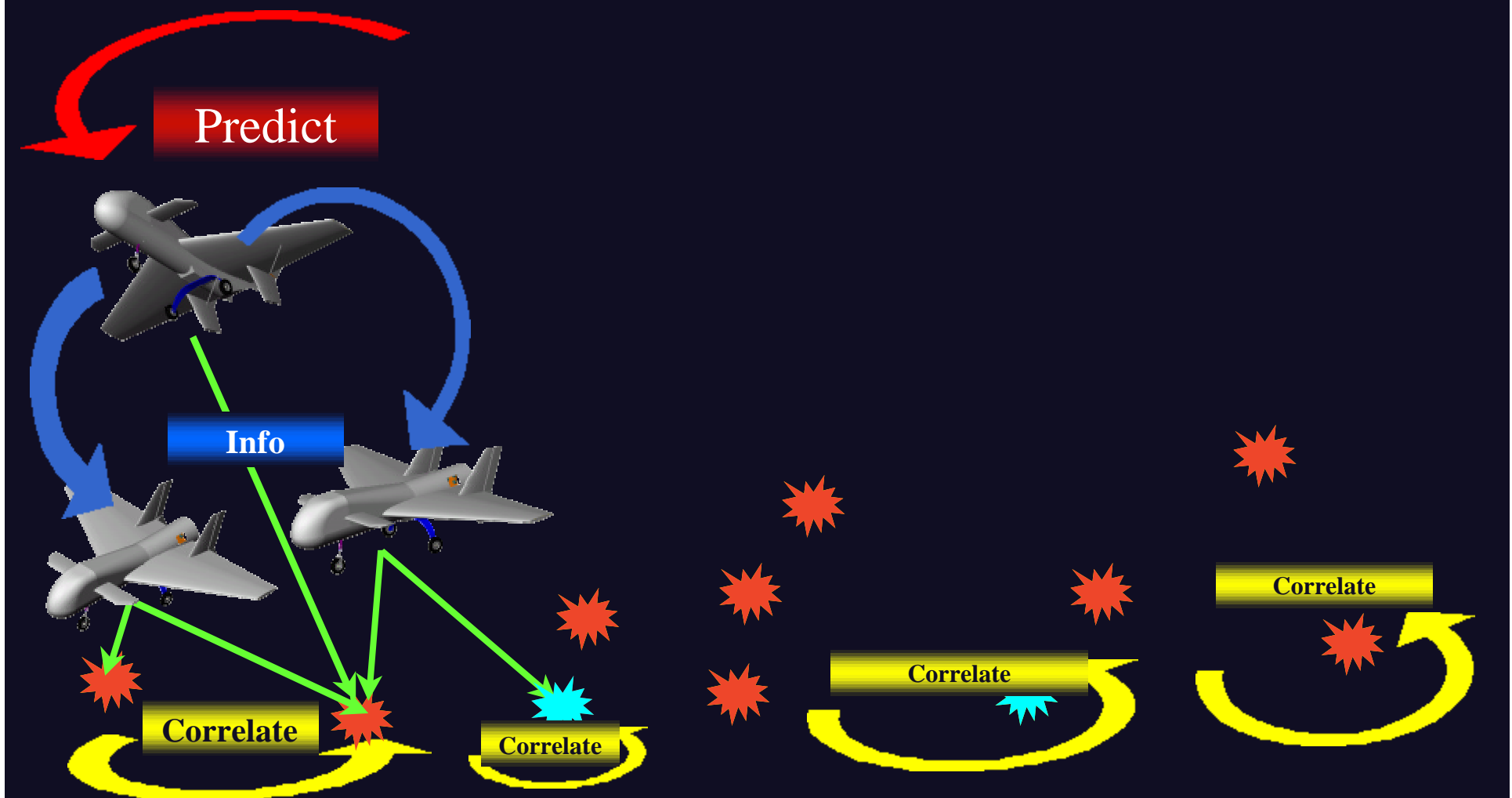
- Multi-Sensor SLAM
  - Reduces Sensor pose error
- Multi-platform SLAM
  - Reduces effect of Platform pose error

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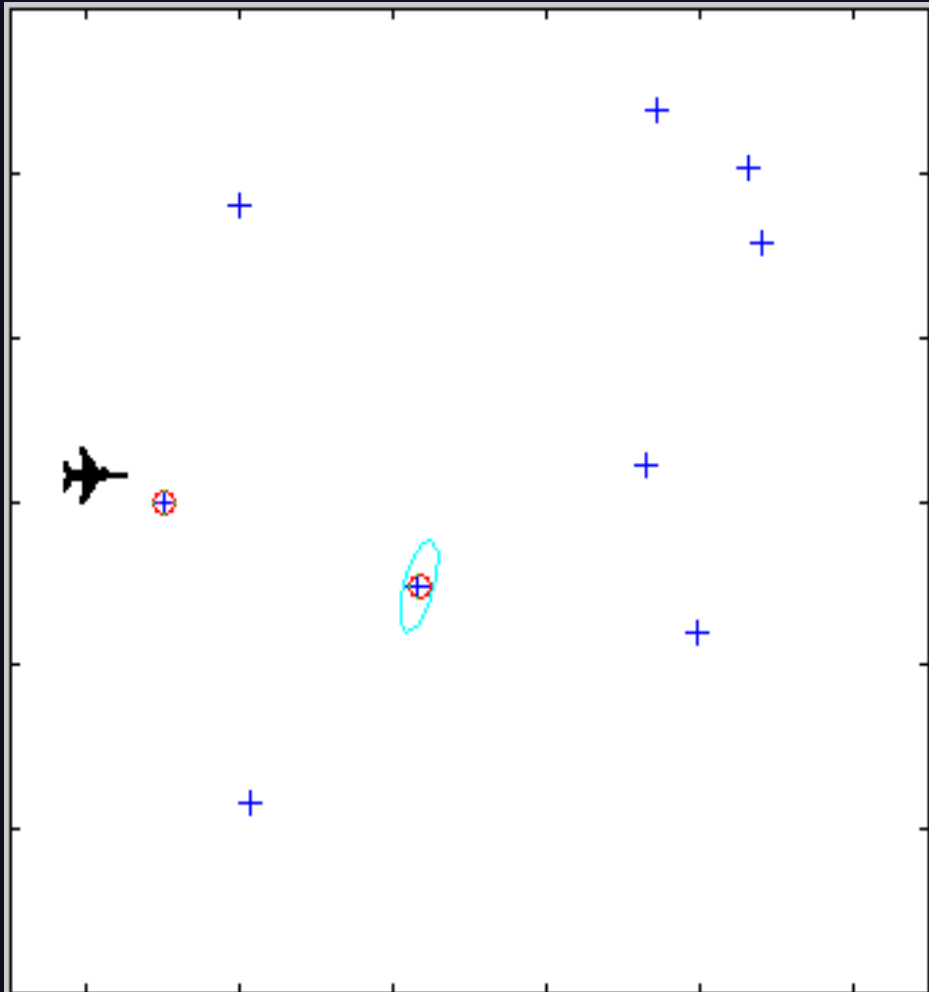




# Sequential map-building

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An Example of Platform and Sensor Management



AC1 with 1st sensor payload.

AC2 with 2nd sensor payload.

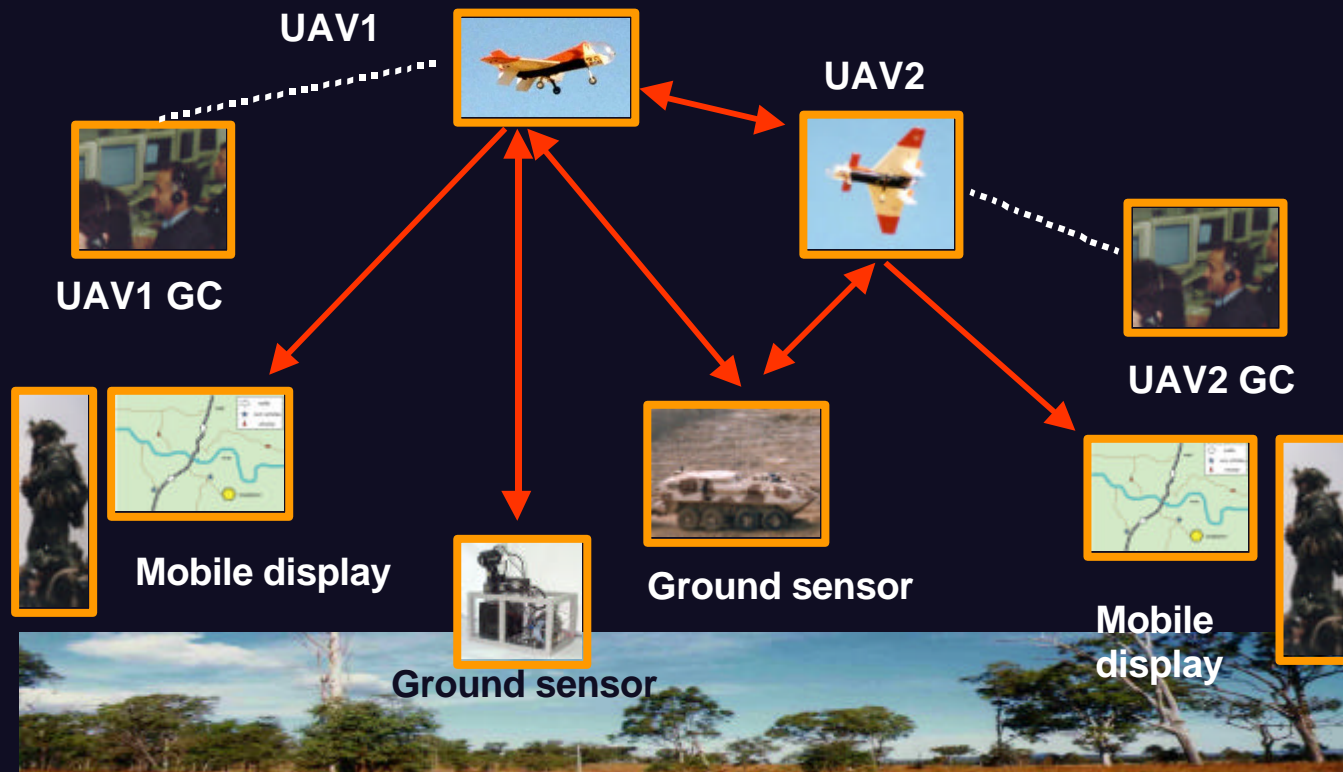
1. FV1 initiates map building.
2. FV1 propagates map data to FV2.
3. FV2 resumes map building and propagates forward updated map estimates to targets not yet seen by FV2, but which affect FV1.

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# Future Demonstrations

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- Multiple UAV SLAM
- Mixed Force network SLAM
  - Australian proposed CTD Programme



Classification

# Summary

- **Mathematical modelling and simulation show**
  - **SLAM provides the means for accurate navigation and target location**
    - **GPS Denied**
    - **No a-priori map data**
  - **DDF provides the means to share map and target data across multiple platforms**
- **Previous land based trials and the latest ANSER flight trials results support the theoretical conclusions**

## **Additional Benefit**

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**Analysis of current UAV Systems performance indicate target  
location accuracy will improve by an order of magnitude  
through the inclusion of SLAM techniques  
  
even when GPS is available**